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Making urban space more accessible for seniors

1 The accessibility of urban space for seniors and the disabled has become a major concern. In this work we will focus mainly on seniors within the framework of urban space. The urban space is a hub for all activities and ambiances and is often designed for hypothetical "standard" people. This prompts the question of why these standards exclude seniors. Those individuals whose age has reduced their ability to dwell in towns and cities and deemed their daily life an obstreperous challenge. The demographic trend of aging populations is increasingly clear, underlining the need to address the mobility

and safety concerns of senior pedestrians. In this context, we have chosen to focus on the effects of senior pedestrians' altered perception of urban sonic ambiances due to presbycusis, particularly when crossing the road.

2 Public actors in urban accessibility, including architects and urban designers, must strike a balance between space creation and social use. This common goal of "fair accessibility for all" cannot be conceived without resorting to the comprehensive concept of ambiance, recognized as an emerging operative entity in urban accessibility and social practices unfolding in the city (Thomas, 2004). The concept of ambiance is loaded with meanings which confer on the physical entity of space, a poetic and multisensorial nature through the perception of its users (Amphoux *et al.*, 2004).

3 Little research in the field of urban and architectural ambiance has focused on specific users such as seniors. The perceiver of ambiance is most often assumed to conform to "a normal person"'s standards, with an average age and free from any form of mental or physical disability which might hinder his or her perception. The progressive aging of populations all over the world obliges us to focus on other sub-populations in a given society suffering from specific disabilities (natural or acquired with age). This study in the field of urban sonic ambiances will focus predominantly on seniors with disabilities, specifically seniors suffering from a loss of high-tone acuity.

4 Proposals to make the city more accessible for the elderly are the subject of ongoing discussion, but much thought should be devoted to the real-life application and effectiveness of such proposals. Several actors weigh on decisions concerning urban accessibility; they all have conflicting goals, resulting in heterogeneous solutions. The question of urban accessibility for seniors is complex and many-sided, not just a matter of "technical" issues. However the rest of this paper will mainly focus on the altered auditory perception of persons suffering from presbycusis in the context of urban sonic ambiances.

Altered perception of urban sonic ambiances

5 The field of urban and architectural ambiances is a comprehensive way of considering the question of seniors' urban accessibility from a "perceptual" point of view, as well as a technical one. Major works in urban and architectural ambiance have yielded solid findings on the hybrid dimension of ambiance, transcending the architectural and social domains but also involving the individual experience of the person perceiving the ambiance (Amphoux *et al.*, 2004).

6 An ambiance is the junction between perception and action. At the same time it is tightly bound to the material and social dimensions of the world in which live. The concept of ambiance is becoming an increasingly important challenge in the architectural and urban research input parameters.

7 For any discussion of sonic ambiances it is essential to clarify the notion of "soundscape" (Schafer, 1977), the aural dimension being essential to any perception. The concept of soundscape was adopted in the late 1990s with arguments which revealed the limited approach to the acoustic environment, usually based on evaluating physical propagation and sound levels (Schulte-Fortkamp & Dubois, 2006). The soundscape characterizes a particular context in terms of time, place and activity. We can thus assume that human

perception is an intrinsic part of it, enabling us to define soundscape as an acoustic environment perceived and understood by a person in a given context (Brown, 2011).

8 Analysis and perception of a soundscape encompass all sound sources, targeted and disregarded. Managing and overseeing these sounds in a given spatial context is central to the principle of "soundscape planning" (Axelsson, 2011). The prime objective, when designing a soundscape, is consequently not to reduce sound levels, rather to determine the suitability of a sound in a given space. In other words, to define how it will evolve over time and be used in an urban space (Brown & Muhar, 2004).

9 This study focuses mainly on a specific class of population whose auditory perception has been affected by presbycusis, a natural, age-related loss of hearing, and that within the context of urban space. The use of the urban space is based on a balance between the person perceiving the ambiance, the pedestrians moving in a given space, and its physical and sensory configurations. As a result, any alteration in the aural perception of the urban space may upset this complex equilibrium. More specifically, it may affect the accessibility of senior pedestrians and create hazardous situations when crossing roads (Saby, 2007).

Pedestrians suffering from presbycusis and hazardous situations in the city

10 Many studies of ambiance have confirmed that human perception cannot be reduced to a simple addition of physical phenomena. Rather it entails complex interaction between physical (sound, light, heat, wind), physiological (heart rate, electrodermal activities) and cognitive dimensions as well as sociological factors (attention, emotion).

11 As we grow older, a substantial number of people start to experience physical and cognitive deficiencies causing sensory impairments leading to hearing loss. However slight it may be, this age-associated hearing loss, known as presbycusis, is a major contributing factor in traffic accidents affecting senior pedestrians in the city (RENES, 2007). The loss of sound distinction due to hearing deficiencies hampers interaction with the environment, leading to potentially dangerous situations, lack of awareness and improper localization of moving sound alarms and vehicle horns when crossing roads.

12 As people age and are affected by peresbycusis their perception of sounds and high frequencies diminishes considerably, altering their appreciation of distance and localization of moving sound sources (Dobreva, 2010). Mobility-related safety issues thus become a growing concern for pedestrians with presbycusis.

13 Making the city accessible (Thomas, 2005) and safe for seniors with impaired hearing is difficult. An auditory disability is generally not readily apparent for people, [non-sequitur] challenging the majority of urban measures in cities which only take into account the visual and physical aspects. Hearing impairment is often ignored and may be perceived as a source of stress in city-related activities and further intensified by other age-related issues such as physical/mobility problems. The urban sonic environment is extremely intricate, so senior pedestrians must pay close attention to accurately decode it and take the right decisions.

14 The altered aural perception caused by presbycusis can be a source of stress for seniors, particularly at street crossings. Despite the fact that most city crossings are regulated by traffic lights, they are the cause of great anxiety among senior pedestrians. The issue of

safety for the elderly is and demands a compromise between the design of potentially dangerous urban configurations [non-sequitur] and how senior pedestrians' with a hearing deficiency experience them daily.

15 To analyze these relations and interactions, we carried out a field study which demonstrates three aspects of experiencing potentially altered urban sonic ambiances in the city. Specifically we considered:

- The urban design aspect of existing street crossings considered as potentially dangerous for senior pedestrians (based on statistical analysis).
- The graphical representation of the urban space configuration, using the audio textures technique.
- An evaluation of senior pedestrians' stress level when thinking and taking decision regarding city traffic, crossings or any aspect related to such configurations.
- Records of subjects' comments on "relevant" sonic events.

16 It is important, before detailing the experimental protocol we carried out and its results, to define the third aspect related to urban sonic ambiances, and to identify which part of the sonic ambiance is relevant to a person suffering from presbycusis and holds the most information to help him or her to cross the road safely.

Urban sonic ambiance, sound events and graphical representation of audio textures

17 Due to presbycusis, senior pedestrians do not necessarily perceive the urban sonic ambiance as a whole. Most importantly sound events (car hooters, ambulance sirens, etc.) guide senior pedestrians and tell them how far off or close hazards may be. Each sound event, produced by a source, carries information:

> "Looking at the urban sonic environment as a negative concept, urban designers have forgotten that sounds carry out information" (Baläy, 2006)

18 In the case of a pedestrian with presbycusis, car horns for instance are typical sound events which emerge from the background ambiance and warn them of an approaching hazard (namely a vehicle). Let us explore this relation between sonic ambiance and sound events using a new class of sounds called audio textures[1].

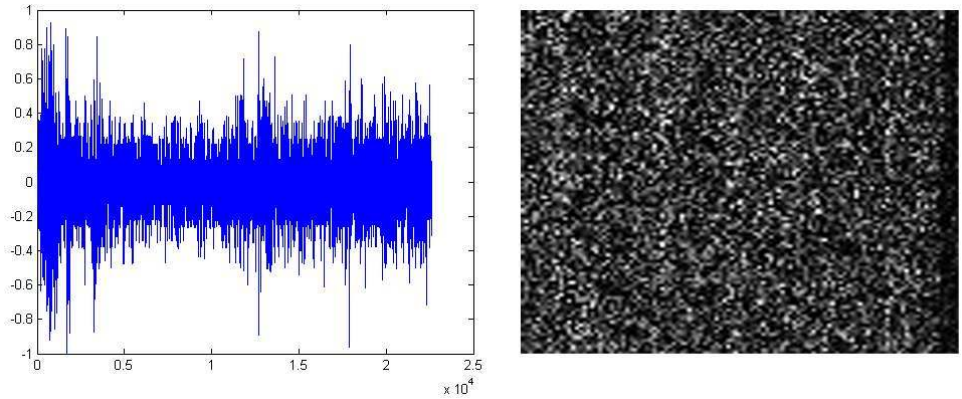
Audio textures : a conventional definition

19 In conventional audio processing, the different sounds are categorized as either: musical sounds, environmental sounds, or speech signals. An alternative way of viewing most background noises is to use the emerging class of "audio textures", as it covers a wide range of sounds such as the crackling of fire, rain or wind, crowd cheering, applause, etc. This class of sounds applies to those which have common temporal and spectral characteristics (Lu *et al.*, 2004).

20 With a clear reference to visual textures, several studies have attempted to define audio textures without agreeing on a single definition. We prefer the definition of Dubnov and Filatriau. In their work they specify that an audio texture is:

> A set of repetitive structural elements with a random distribution in their temporal aspect and layout. However, they preserve some temporal and spectral coherence (Filatriau, 2004).

Illustration 1: Example of an audio texture sound of “rain” mapped in two dimensions (greyscale image) and the associated audio signal temporal variation (left).



Source: Hussein, Faten. 2012. p. 55.
Copyright : Faten Hussein.

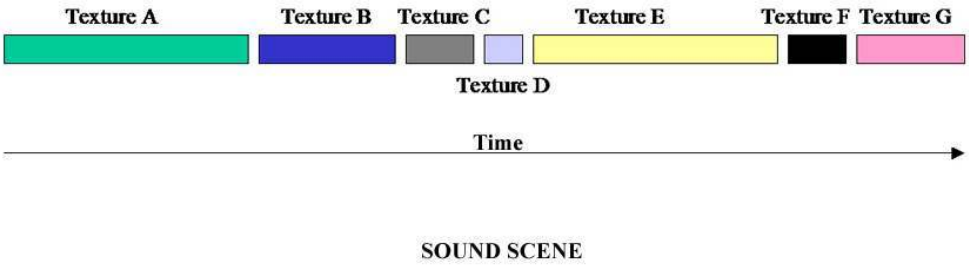
21 According to this definition, if the texturing level reflects the stationary state of a sound, the sound in question will retain its homogeneity, acoustic properties and perceptual fluctuations thanks to its minimal temporal structure. Consequently, the intensity of the sound will not vary abruptly. Several audio-textures-synthesis applications have been produced to simulate and create background sounds in movies, video games and other domains which require sounds to generate environments with a rich ambiance. Thus, the synthesis of audio textures complements the creation of realistic “ambiances” especially for virtual-reality systems.

Audio textures: an ambiancial definition

22 As a part of the urban sonic environment, audio textures are also an integral component of human life, playing an important role in auditory perception. Regardless of age a pedestrian continuously monitors the surrounding (visual, sonic, olfactive) environment and tries to interpret it. Audio textures consequently have a significant impact on the listener’s cognitive and affective states while at the same time conveying information and meaning like any other audio signal.

23 One can safely argue that an urban sonic ambiance is a coherent composition of audio textures punctuated by the emergence of sound events. This dynamic aspect makes it difficult to quantify the information conveyed by the ambiance, even if we can measure its complexity through entropy[2]. Characterizing the urban sonic ambiance would be similar to characterizing textures and defining the inter-temporal relations between them.

Illustration 2: Breakdown of a sound scene into a sequence of audio textures in a given urban sonic environment.



Source: Ben Hadj Salem, Mohsen. Fraj, Olfa. Ghozi, Raja *et al*. 2010. *Perceptions altérées des ambiances sonores en milieu urbain : Caractérisation et corrections : apport des textures audio*, p. 17.

24 When sound events appear in and mix with an urban sonic ambiance, their perception becomes far more complex: human hearing can analyze this complexity but we are nevertheless unable to say whether age-related hearing deficiencies hinder correct decision-making. Furthermore, to compensate for their hearing disabilities and avoid accidents, pedestrians with presbycusis tend to develop and adopt certain strategies when crossing some urban configurations, which would only increase the difficulty of perceiving and analysing the soundscape.

25 Unlike conventional techniques for analyzing audio signals, audio textures offer a new graphical approach to analyzing urban sonic ambiances. In fact, this improved method can translate any complex sound scene into a series of grayscale images indicating the emergence of sound events (Ghozi *et al.*, 2007). In this work we will consequently use such audio-to-visual features and techniques to monitor and confirm our psycho-physiological and social studies' results regarding the safety of senior pedestrians in urban spaces. These graphical tools offer architects and urban designers meaningful, effective methods to delineate and portray urban sonic phenomena as well as potential urban hazards.

26 Far from the iconographic maps or the normative maps which represent sound levels in the city, we hope to capitalize on the potential of audio textures. Indeed, audio textures can translate a sound scene into a textured image that can be used later to display sound events. One may therefore imagine that the urban sonic ambiance is similar to a "musical partition", audio textures being its "notes". If you hit a wrong note (a non-textured sound event), it would not only be heard but also seen graphically !

Detecting the "hazardous" situations faced by pedestrians with presbycusis by representing audio textures visually

27 The graphical method previously submitted will be further developed to help detect situations of "sonic" danger faced by seniors with presbycusis in urban spaces. We seek, in particular, to draw parallels with specific perceptual features of sonic ambiances,

through comparative analysis of visual representations of sound-scene segmentation, commented walks and psychophysiological measurements reflecting human stress levels in such situations. We will then detail the protocol of the experiments carried out in this study; in particular the space configurations, the physical and physiological measurements and, last but not least, the subjective assessments of study participants.

Experimental protocol

28 An experimental protocol is established and correlates the three aspects of data collection:

- An identification of some urban configurations where the safety of senior pedestrians is endangered,
- A selection of a target population which will experience the study's identified field by carrying out commented walks. We will also track their stress level during these experiments via a biosensor which maps their electrodermal activity.
- A change detection approach of the stressful sound scene recorded via audio-visual texture transformation.

29 This original approach was defined according to the exploration of the audio texture-based approach's limits and merits as well as its ability to characterize urban sonic ambiances (Hussein, 2012).

Identification of urban configurations which increase the incidence of accidents

30 We drew on the field of accident studies to select urban configurations to test our experimental protocol. This scientific discipline provides information on road accidents including a description of the circumstances of and the actors in such events. According to this discipline, the police identify road accidents by drawing up injury reports summarizing the accident scene. These computer files help to understand and analyze the course of an accident, from the moment the driver enters his or her vehicle to the time of collision with the pedestrian.

31 We consequently need identify the urban configurations which increase the incidence of accidents by applying a model commonly used in the field of accident studies, known as "a prototypical accident scenario"[3] (Fleury & Brenac, 2001). We can define a prototypical scenario as a standard accident process corresponding to a group of accidents displaying overall similarity in terms of events sequence and causal links, throughout the successive stages leading to the collision.

32 In the context of Tunisia, we need similar databases to apply and experiment the protocol we developed and choose our fields of study. Nonetheless, for reasons of confidentiality, several administrative bodies denied us access to databases such as injury reports. These bodies are controlled by the Ministry of Home Affairs which refuses to disclose any data related to accidents as they might reflect poorly on government policies, attesting to their effectiveness or ineffectiveness in terms of road safety.

33 Due to this unexpected difficulty, we decided to base the investigations on detailed analysis of accident cases involving senior pedestrians in Nantes (between 2000 and 2008) [4]. Considering the model of prototypical scenarios, we tended to group similar cases of

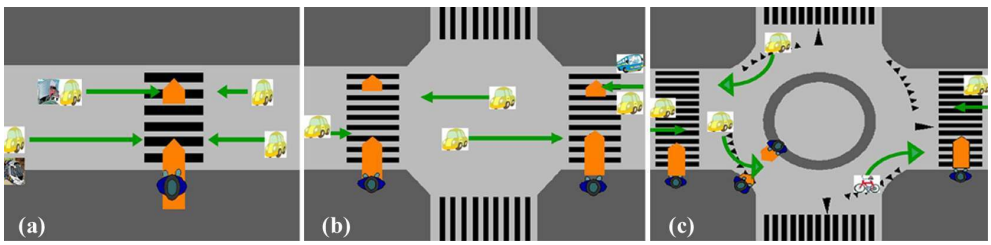
accidents according to the studied model and we identified three urban configurations with a high accident frequency and similar scenarios: conventional crossings, crossroads and roundabouts.

34 This methodological flaw is not without repercussions. As a matter of fact such results should not be transposed from one field of study to another without taking into account the cultural background in which the data was originally collected. This transposition is undoubtedly a weakness in our experimental protocol.

35 Recognizing this problem, we selected carefully for our study three strategic urban configurations in Tunis to conduct the experiments:

- The first urban configuration is associated with conventional road intersections; we chose an area in Tunis called Beb-El Falla, where traffic congestion is severe due to the proximity of a market place. The crossing is not regulated by traffic lights and vehicles move in two directions (see figure 3). A senior pedestrian is required to make a considerable effort to decide at any given moment if it is wise to cross. This area is particularly characterized by heavy traffic and a frequent use of vehicle horns.
- The second urban configuration is a crossroads in the Lafayette area of Tunis. The crossroads we chose is regulated by traffic lights. This configuration is more complex than a simple road intersection (see figure 3). A part from the large flow of vehicles through this crossroads, we noticed a significant number of pedestrians who use it. Due to the administrative nature of this area, motor and pedestrian traffic decreases considerably on weekends and after 7 pm.
- The third and last urban configuration is a roundabout, a complex urban structure which requires a special kind of attention and concentration on the part of senior pedestrians in order to cross it. We chose a typical area in downtown Tunis with a similar configuration, the Habib Bourguiba Avenue. This configuration is known to be problematic to cross; it is regulated and controlled by traffic lights as well as traffic police, who are in fact continuously present in order to supervise traffic flow (see figure 3). Among the largest and busiest in the capital, this roundabout is strategically located, regulating the flow of vehicles accessing the downtown area and connecting the main roads leading to the suburbs of Tunis. It consists of an accessible central area made up of a fountain and a giant clock surrounded by grass. Observations have shown that this central reservation acts as a rest area or simply as a transitional area leading to the other part of the avenue (see figure 3 (c)).

Illustration 3: Schematic representation of three accident-prone configurations in city traffic: (a) conventional intersections, (b) crossroads and (c) traffic circles



Source: Hussein, Faten. 2012. p. 126, 129, 132.

36 The statistical study we carried out while identifying the three urban configurations mentioned earlier showed that senior pedestrians are usually victims of accidents at the

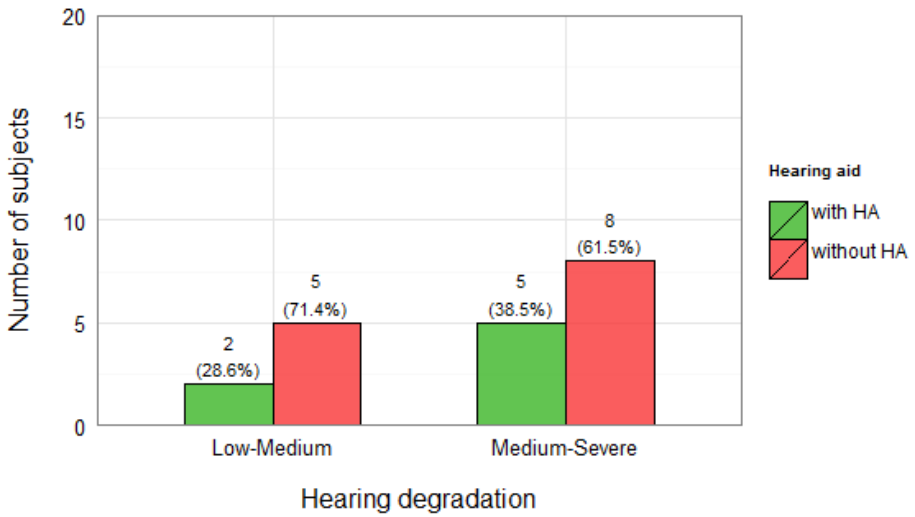
end of crossings; this is due to a decrease in their motor and perceptual skills. In fact, it is extremely difficult for senior pedestrians with hearing loss to decide the right time to cross a road as they often miscalculate the time interval needed thus inevitably leading to accidents. This is precisely why we decided to study urban configurations (roundabout and crossroads) which are complex but regulated by traffic lights.

37 The subjects selected to take part in the study consisted of 20 seniors equally split between males and females. They had no physical or mental health issues but suffered from various levels of presbycusis. A third of the subjects were wearing hearing aids (Hussein, 2012).

Commented walks and measures of stress

38 We selected a target population of twenty seniors with different degrees of presbycusis and conducted hearing loss evaluations via audiograms in close cooperation with audioprothesists. The levels of presbyacusis degradation fall into two categories: low to medium (hearing loss of 50 dB to 70 dB) and medium to deep (loss of 70 dB to 100 dB or more) auditive degradation. A third of the subjects were wearing hearing aids (see figure 4).

Illustration 4: Population profiles - distributions based on the level of presbycusis deficiency, with or without a hearing aid.



Source: Hussein, Faten. Gozi, Raja. Bahri, Houda. 2014, p. 250.
Copyright : Houda Bahri, Raja Gozi, Faten Hussein.

39 We noticed through audiogram tests carried out by audiologists that age is strongly bound to seniors' degree of decibel loss. As participants grew older, their losses in decibels were much higher, particularly when their ages ranged from 70 to 80 years old. In such delicate cases, hearing aids are a necessity to correct seniors' hearing degradations. This clearly demonstrates the inextricable link binding each subject's age to his/her degree of presbycusis as well as the role played by hearing aids.

40 Each subject performed a commented walk (Thibaud, 1998) in each accident-prone configuration previously identified while describing what she/he heard. The aim of these

walks was to obtain a full record of the multisensorial perception in movement and the audio perception in particular. Nevertheless for various reasons, the task proved to be laborious and difficult.

41 The first challenge we encountered mainly concerned audio perception. Due to their audio deficiencies the subjects resorted to a process of auto-compensation, through other sensorial channels, while describing and commenting their walks. We even observed comments based on memory rather than real-time impressions. Thus we had to subtly refocus the subjects' comments without irritating or offending them. When attending to seniors, one must take into consideration their fragile psychological state. Hence, we had to constantly reassure the participants and avoid pressuring them with excessive insistence on focusing solely on what they discerned during the experiment.

42 Due to the advanced age of the subjects, we had to assist them during the walks without influencing their behavior or decision making. Among the difficulties dreaded by most of the participants was crossing roads due to the complexity of the task and the perceptive, cognitive and motor skills involved. We noted that a majority of the participants spent a great deal of time observing and visually exploring their surroundings to select a suitable and precise route. Certain participants requested our opinion. As a result we had to constantly remind them that we were mere observers and that they were free to decide their own actions in relation to the experiment.

43 While assisting the participants, we paid particular attention to behavioral indicators more likely to help us understand the relation between each subject and their surroundings. Consequently, we noted with varying degrees of accuracy:

- The subjects' spatial marks, positions, movements and behaviour when evolving among other pedestrians.
- The subjects' speed, gestures, chosen itinerary, breaks and rest times during the commented walks.
- The participants' body language and reactions following auditory stimuli or when asked to describe audio phenomena.

44 We also asked participants to provide continuous spatial clues as they progressed and the experience unfolded. The different walks were carried out in constant and homogenous weather conditions, over the required period and throughout the three pre-selected sites and 60 itineraries.

45 During the commented walks, each subject wore a wireless biosensor which measured his/her emotional arousal level via skin conductance. Emotional arousal is a form of electrodermal activity that increases during states of intense concentration, anxiety or excitement and decreases during states of boredom, relaxation or indifference. Additionally, the sensor measured the participants' temperature and speed but also tracked their stress level (Healey & Picard, 2005).

46 Using this psychophysiological method was a pertinent and efficient method which helped us detect stressful events even if the subject did not verbally express them during the commented walks (Ghozi & al., 2011) due to his/her hearing loss. The biosensor captures the electrodermal activity by passing a minute amount of electrical current between two electrodes in contact with the person's wrist thus measuring skin conductance (in µSiemens) (see figure 5) (Poh & al., 2011). When using this biosensor, it is important to properly adjust it and ensure it is on to allow at least five minutes' adaptation time. The walks carried out in this study were at periods of high traffic and

during daytime. Each time a subject was undergoing stress; this phenomenon was translated graphically on the electrodermal activity curve demonstrating a disturbance in the recorded line. This disturbance is referred to as an electrodermal reaction and can be specific (with an identified stimulus) or non specific.

Illustration 5 : The Q-Sensor for electrodermal activities measurements.

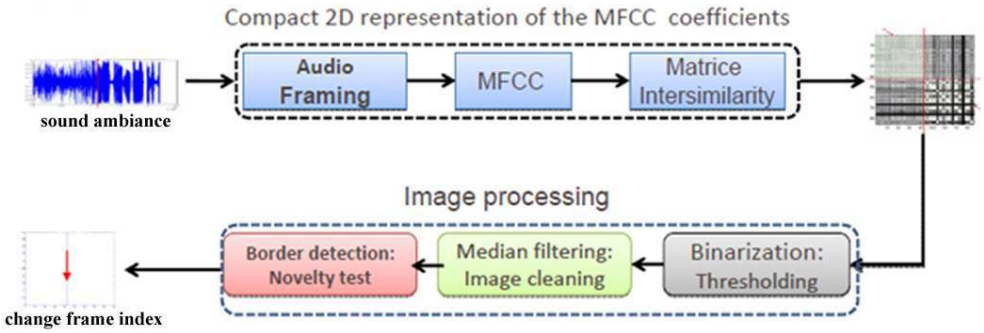
Source : Hussein, Faten. 2012, p. 152-153.
Copyright : Faten Hussein.

Segmentation of urban sound scenes

47 The latter part of our study consists in analyzing the sound scenes that occurred in the three major accident-prone urban configurations using the audio textures segmentation technique. In fact, apart from recording pedestrians' comments during the performed walks we used simultaneously a second calibrated sound recorder to track the different audio signals. In addition, we took various precautions which included keeping the second sound recorder at a certain distance from the original one used to record the comments, in such a way as to avoid any interference between speech and sound scenes.

48 Thanks to the physical domain of sound treatment, we applied to each recorded sound scene during the walks an algorithm of segmentation (Ghozi et al., 2007) which computes the similarity between any two frame vectors of a signal. The similarity matrix makes it possible to visualize a sound structure via its acoustic self-similarity across time, rather than by its absolute characteristics. The resulting imagery contains the quantitative similarity between all paired audio-timeframe combinations. The result of such an operation is a textured grayscale image where we can see and localize the modifications of sonic ambiances and the emergence of sound events when they occur. The different steps of the sound scene segmentation are represented as follows:

Illustration 6: Example of algorithm stages of sound scenes segmentation



Source: Ghozi, Raja. Fraj, Olfa. Jaidane, Meriem. 2007. p. 1532.
Copyright : Raja Ghozi, Olfa Fraj, Meriem Jaidane.

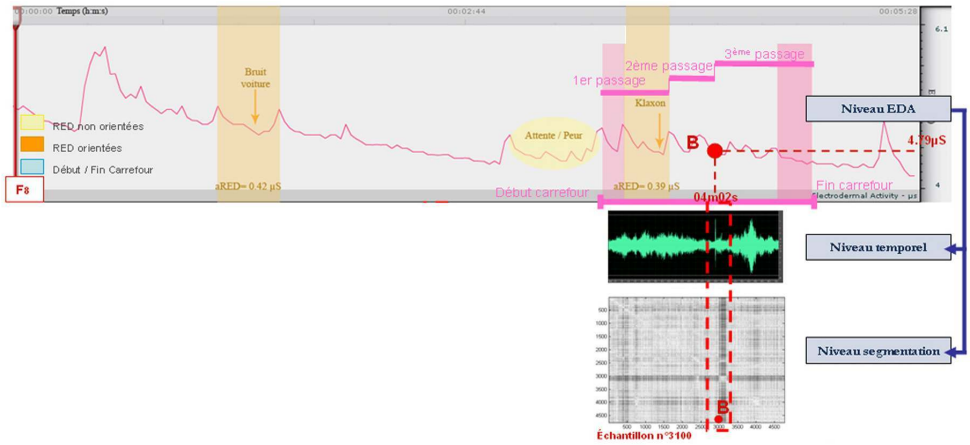
Results and analysis

49 For each participant in the study we cross-correlated both the electrodermal activity and the commented walks with a reference to the segmentation of the recorded sound scene via the visual texture technique. This was carried out for all twenty participants. Each level of a sound scene's representation informed us on a particular aspect of the urban sonic ambiance and its perception.

50 The senior pedestrians's electrodermal reaction, due to a stressful sound event (orally expressed or not during the commented walk) is interfaced with the segmentation of the sound scene in time and space. Thus, the emergence of a stressful sound event can be expressed graphically. So we compared two levels of sound representations:

- The electrodermal activity level (1) with the sound sources and events identified by senior pedestrians during their commented walks.
- The sound-scene segmentation level (2). This level seeks to explain and adjust its results by contrasting both the participants' commented walks and EDA results (drawn from the electrodermal activity level (1)) with the sound scenes as perceived and translated by audio signals, thus attempting to express the subjects' experience as well as reflecting the urban space's sonorous aspect.

Illustration 7: Time evolution of EDA levels for subject F2, and corresponding soundscape segmentation.



Source: Hussein, Faten. 2012, p. 225.
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51 When a senior pedestrian suffering from presbycusis crosses a given intersection, he/she may not be able to identify an approaching vehicle due to lost high-frequency content. For a further detailed illustration, we analyzed a specific sound scene with the proposed segmentation algorithm. The resulting grayscale image represented the segmented scene where each pixel is given a grayscale value proportional to the similarity measure: the higher the similarity, the brighter is the pixel.

52 We then proceeded to define the electrodermal reaction's temporal coordinates (see point E in figure 7 above) expressing stress during road crossing. We matched and compared the EDA plot with the sound scene's segmentation by scanning the inter-similarity matrix. Finally, we relatively accurately determined the sequence's time frame index which corresponded to the exact moment of the event of danger which may not have been identified by a pedestrian with presbycusis. Thanks to this correlation, these "textured images" offer a new, yet simple key graphic indication to architects working on city accessibility for persons with a hearing deficiency. In fact, it enables them to minimize and alert in case of potentially alarming situations confirmed by their Electrodermal Activity level.

53 At present the integration of sonic ambiances can only be integrated in the architectural or urban design if architects and urban planners can represent them and assess the possibility of their use in the initial stages of architectural or urban projects. Within the framework of these conclusions, the results of our research will serve to enrich our current knowledge and understanding of the urban soundscape analysis, design and mappings fields as well as in geographic information systems by offering a graphic approach for analyzing and describing soundscapes in a real-time context (Hällgren, 2011), the segmentation of sound scenes through its "textured images" is a relevant, applicable tool in soundscape mapping.

54 As our experimental protocol combines qualitative[5] and quantitative methods of characterizing sonic ambiances, it helps improve sound mapping representations since it integrates multiple forms of representations including physical and physiological (via EDA levels) in addition to signal processing tools (via sound scene segmentation).

Statistical studies can contribute to produce a model which could be applied to a specific urban space and its corresponding soundscapes (Bahri *et al.*, 2014). Hence, databases of "textured images" may be produced and used by urban planners when designing spaces for the elderly as well.

Conclusion

55 In this multidisciplinary work, we focused on auditory altered perception of sonic ambiances, and gave indications on how an architect or an urban planner could integrate such specificities in soundscape analysis and synthesis. The graphical stage of any project realization would be enhanced with sound mappings convenient to a certain class of population, namely pedestrians suffering from presbycusis, thereby enhancing the chances of their situational awareness and safety level during road crossings. The perceived complexity of such sonic ambiances will be tackled through a dual urban ambiance/"audio textures"[6] formulation directly linked to dual urban/ ICT[7] approaches. Therefore, urban designers have to take into consideration new practices while establishing rules for equal accessibility of urban spaces by all users, particularly for persons with presbycusis.

56 Through these correlations between various physical, physiological and subjective feedbacks, we were able to qualify the informational content of sonic ambiances in our case studies so as to detect any sound scenes' modifications, which might not be perceived by seniors with a hearing loss, and to demonstrate them through an innovative graphic method using segmented images. On that account, any dangerous situation triggered by the emergence of a sound event and non-identified by senior pedestrians will be subject to detection, developing therefore a secure and accessible city for all its users, including seniors with hearing deficiencies, while avoiding potentially disabling spaces.

57 The study's affective dimension, captured via the electro-dermal activity (EDA) and the subjects' cooperation and real-time comments, represent a new promising and powerful feedback on the perceptual dimension of a given class of population. A deeper analysis of the EDA data, with the participation of not only architects but also urbanists, and ICT professionals; it is important as well to consider the feedback from environmental and human psychology specialists in order to ratify, confirm and encourage similar multi-disciplinary projects on urban soundscape design. The ability to personalize a given soundscape design while taking into account, gender age, mental and physical conditions within a specified class of population is a significant step forward in today's world, a world where we are frantically and hectically seeking the optimum while aspiring to soundscape comfort and stress regulation.

58 Finally, it important to note that focusing on soundscape does not ineluctably exclude ambiances' other major sensorial components and the roles they play in defining and outlining the general framework encompassing and depicting pedestrians and city users. We have to mention that the impaired hearing ability of our elderly subjects is inevitably associated with an alteration of other sensory channels, as well as the motor function. The conclusions we have drawn have to take into account other aspects of aging which affect safety in the city.

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NOTES

1. These studies were carried out under a CMCU french-tunisian project (2009-2012) which included french partners (CERMA, CRESSON, IRSTV) and tunisian partners (ERA, U2S).
2. Measures of sound complexity based on thermodynamic entropy.
3. This model, developed by INRETS in France (Institut National de Recherche sur les Transports et leur Sécurité / National Institute for Transport an Safety), consists in classifying accidents according to the similarity of their events and causal links.

4. In the city of Nantes.
5. There already exist other qualitative approaches for instance the measuring soundscape quality method, known as the Swedish Soundscape-Quality Protocol (Axelsson, Nilsson & Berglund, 2009). It consists on a model that establishes a meaningful relationship between emotional responses and perceived sound sources. This provides urban planners with an idea on how to actively design soundscapes.
6. An audio texture should exhibit similar characteristics over time. It can have local structure and randomness but the characteristics of the fine structure must remain constant on the large scale.
7. Information and Communication Technologies.

ABSTRACTS

Within a universal context of an aging population along with an increasing consciousness regarding senior pedestrians' safe access to the city, we examine the case of seniors affected by presbycusis, specifically their altered perceptions of the urban sonic ambiances during their daily journeys through the city. In this study, we present the urban configurations in which alarming situations were encountered by senior pedestrians suffering from presbycusis. We then construct an experimental protocol correlating collected data including audio signals, commented walks and physiological measurements of stress level generated while crossing the urban configurations previously identified. This cross-analysis process may provide urban planners with two-dimensional graphic representations intended to detect hazardous situations in order to anticipate them and minimize their effects.

Dans un contexte mondial de vieillissement de la population, les personnes âgées sont très vulnérables en milieu urbain, particulièrement lorsqu'elles souffrent de presbyacousie qui altère leur perception de l'environnement sonore. Dans cette étude, nous identifions les configurations urbaines dans lesquelles des situations de danger rencontrées par ces personnes apparaissent. Nous construisons ensuite un protocole expérimental corrélant des données issues de parcours commentés, des mesures physiologiques du niveau de stress engendré lors de la traversée des configurations précédemment identifiées et un traitement physique du signal sonore enregistré. Ce traitement se décline sous la forme de plusieurs représentations graphiques qui permettraient de détecter ces situations de danger et de fournir ainsi aux décideurs urbains un outil graphique prédictif.

INDEX

Mots-clés: textures audio, ambiances sonores, complexité, personnes âgées presbyacousiques, segmentation, situations de danger, niveau de stress, perception altérée, activité électrodermale
Keywords: audio textures, sonic ambiances, complexity, presbycusic seniors, segmentation, hazardous situations, stress level, altered perception, electrodermal activity

AUTHORS

FATEN HUSSEIN

ERA, Research Team on Ambiances, National School of Architecture and Urbanism of Tunis, University of Carthage, Tunisia, faten.hussein@gmail.com

RAJA GHOZI

U2S, Research Unit on Systems and Signals, National School of Engineering of Tunis, University de Tunis El Manar, Tunisia, u2s@enit.rnu.tn

MÉRIEM JAÏDANE

U2S, Research Unit on Systems and Signals, National School of Engineering of Tunis, University de Tunis El Manar, Tunisia, u2s@enit.rnu.tn

JEAN-PIERRE PÉNEAU

ERA, Research Team on Ambiances, National School of Architecture and Urbanism of Tunis, University of Carthage, Tunisia

CERMA, Laboratory Architectural and Urban Ambient Environment, National School of Architecture of Nantes, France, jean-pierre.peneau@wanadoo.fr